THE RELATIONSHIP BETWEEN FLOWS IN THE YAMPA RIVER AND SUCCESS OF RARE FISH POPULATIONS IN THE GREEN RIVER SYSTEM

PR-31-1

BIO/WEST, Inc.

Aquatic and Terrestrial
Resource Management and Problem Solving

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Submitted to

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February 29, 1980

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INTRODUCTION

The National Park Service is in the process of quantifying their reserve right claim for water levels in the Yampa River of Colorado within the boundaries of Dinosaur National Monument. The Monument's need for water is based on a number of factors which are inherent in the reason for its formation, i.e., the natural features that it protects and manages for the people of the nation. One of these factors is the habitat of several fish species endemic to the Colorado River system. Two of these species, the Colorado squawfish (Ptychocheilus lucius) and humpback chub (Gila cypha), are listed as endangered; while two others, the bonytail chub (Gila elegans) and the razorback sucker (Xyrauchen texanus), are proposed for listing.

Data collected over the last 10-20 years in the Colorado River system have indicated that loss of flow may be one of the major factors affecting the endemic fishes, especially Colorado squawfish (Joseph et al. 1977; Holden 1977; Holden 1979). Two major influences of flow on these endemic species are hypothesized.

1. Reduced flows due to regulation of the rivers in the Colorado system have tended to alter the instream habitat to the detriment of the rare fishes.
2. Successful reproduction of Colorado squawfish, and perhaps the other species, is dependent on natural or near natural flows.

The first hypothesis is supported by data indicating that as areas of the Colorado River basin have been developed, and as flows are appropriated for out-of-stream activities, these fishes have shown a reduction in numbers and in some cases have been locally extirpated (Miller 1961; Minckley and Deacon 1968; Holden et al. 1974; Joseph et al. 1977). This is probably the major reason these fishes are endangered today. Most of the habitat alteration has occurred in the lower Colorado basin. There has been some recent speculation that reduced flows are affecting habitat in the upper basin also, and therefore the last remaining populations of these rare fishes (Holden 1979).

The second hypothesis is supported by data collected recently on Colorado squawfish and is the main topic of this report. The objective of this study was to determine the relationship between flow in the Yampa River and reproductive success of Colorado squawfish in the Green River below the mouth of the Yampa River.

METHODS

The primary analytical approach of this study involved the determination of which years Colorado squawfish reproduced successfully, and which years reproductive success was poor, and then a comparison of flows for those good and bad years. Other factors that may have accounted for low success years, such as temperature, were also noted although no indepth analysis was made. Two major sets of data are presented; BIO/WEST data from the Jensen-Ouray area where collections

were made from 1977-1979, and Vanicek's (1967) data from Dinosaur National Monument, collected in 1964-1966. These data represent the results of the only studies where information on reproductive success is available for at least a 5-year period. Information from other short-term studies are included to support or reject the conclusions drawn from these two base studies. Figure 1 is a map of the upper Green River system showing localities mentioned in the text.

Vanicek (1967) showed that young squawfish could be aged quite readily by length/frequency analysis, especially for the first 3 years of life. Older fish were more difficult to age. Therefore, this study concentrated on the first 3 or 4 age groups, young-of-the-year (age group 0), yearlings (age group I), two year olds (age group II), etc. Squawfish usually spawn in July or early August in the upper Green River (Vanicek and Kramer 1969; Holden and Stalnaker 1975), therefore Age 0 fish are found in August-December of a given year, Age I during the next year, and so on. Successful reproduction in an area was determined by the number of young squawfish caught where sufficient effort was expended to ascertain their presence. Sufficient effort was defined as sufficient seine hauls in the habitats most likely to produce young squawfish. Young-of-the-year squawfish are readily caught with seines in August, September, and October. Yearling squawfish are most readily caught in May and June but are found throughout the year, as are age II fish. Age II fish are caught less frequently than either ages 0 or I, which is as expected due to juvenile mortality and perhaps changes in preferred habitat. This approach,

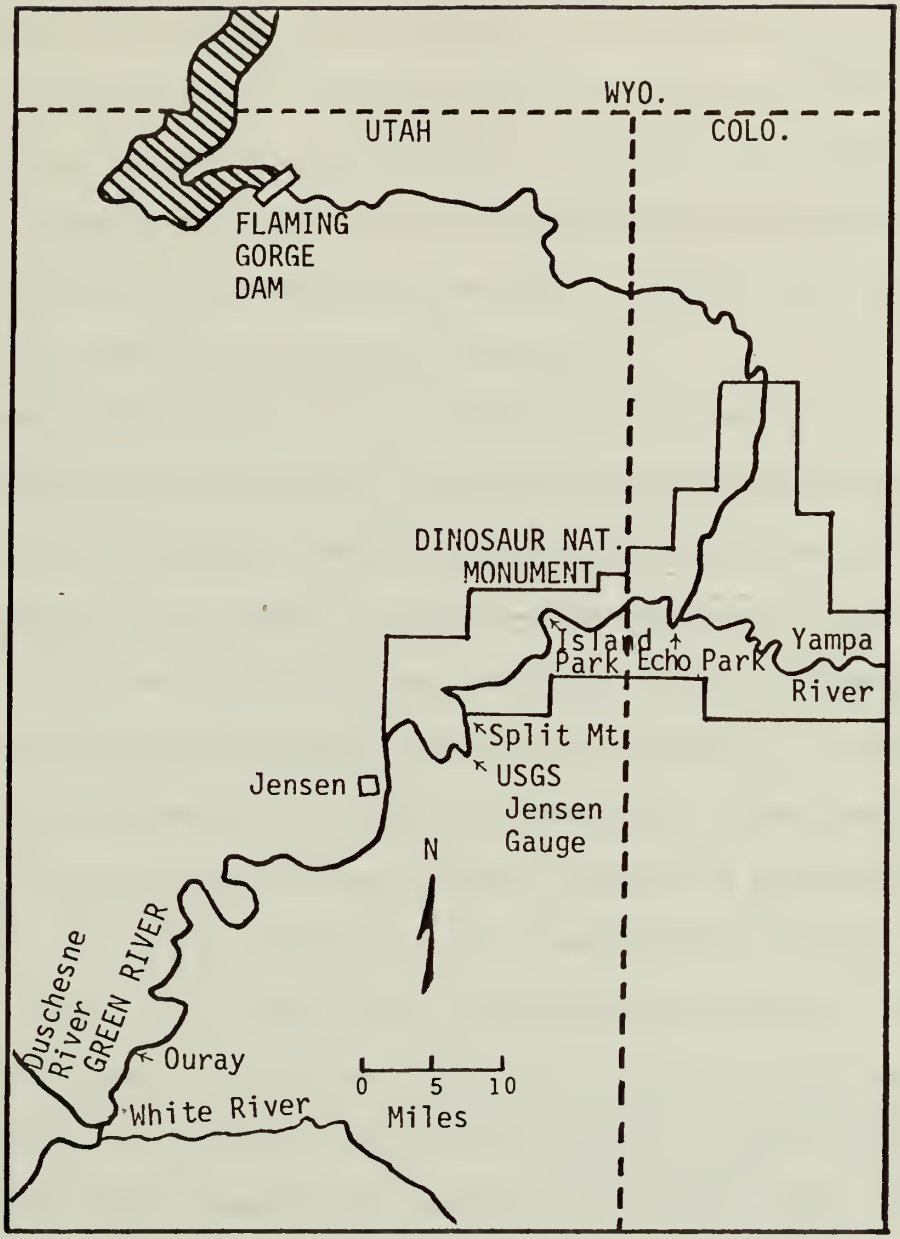

Figure 1. Map of the upper Green River showing areas where young Colorado squawfish were collected.

using numbers of fish caught as an index to successful reproduction, is supported by Vanicek (1967), as well as by Holden (1973), Holden (1977), Holden and Crist (1978), and Holden and Selby (1979). These studies show that strong year classes, as indicated by the location of many young-of-the-year, can be followed and that the cohort remains strong in future years' collections. Likewise, poor years are reflected later by low catches of juveniles.

Care must be used in direct interpretation of numbers of young fish indicating reproductive success unless effort expended, and type of sampling, is known. Sampling with inadequate equipment, or in the wrong habitats, can result in capture of low numbers of young squawfish in river sections where they are fairly common. Squawfish juveniles prefer certain habitats, and are most abundant in these types of habitat (Holden 1977). Therefore, sampling a rather short reach of river may produce very small numbers because few preferred habitats exist in that reach. Therefore, it is impractical to utilize numbers of fish caught as a direct index of reproductive success. Rather, it is more reasonable to consider two levels of success, good and poor. Good success is defined as years where squawfish young-of-the-year were found fairly commonly for the effort expended, and/or when a cohort (year class) is commonly found at Ages I, II, or III. Poor success is defined as year classes when few young or juveniles are found even though sufficient effort is expended. The major method of determining when an age group is "common" or when "few" fish are caught is to compare years of known effort. Therefore, in the tables

of fish presented in this report, each year's sampling will be noted (effort) and the level of success for that year indicated.

Flows to compare with the fish data were obtained from USGS gauging data. The gauge at Jensen, Utah, on the Green River in Dinosaur National Monument near the mouth of Split Mountain, describes the flow from the mouth of the Yampa River to Ouray. The gauge at Greendale, Utah, depicts the flow in the Green River between Flaming Gorge Dam and the mouth of the Yampa River. The only inflow between these gauges of any consequence is the Yampa River. Therefore, the difference between the Jensen and Greendale values was considered to be the Yampa's input.

The hydrographs used to depict the flow are nothing more than graphs of the daily flow at the gauge in question. The time period March-August was used because this is the flow period which generally shows the greatest change and also is the period leading up to and including spawning of Colorado squawfish.

RESULTS AND DISCUSSION

Colorado squawfish are America's largest minnow, apparently reaching lengths of 6 feet and weights of 80-100 pounds at one time. Adults are long-lived, reaching sexual maturity at about 7 years of age (Vanicek and Kramer 1969). Spawning occurs in the summer at river temperatures of near 70° F (Holden and Stalnaker 1975). Young prefer quiet backwaters, where they initially feed on small crustaceans. As they grow older, and larger, they begin to eat larger insects and fish.

By the time they reach about 8 inches, they feed almost totally on fish (Vanicek and Kramer 1969). Adults live in a variety of habitats, apparently changing their preferred habitat with the season.

The following analysis discusses the fishery data collected by year, and compares it to the flow data, shown graphically, for that year. Analysis of original fish data sheets were made so that all data were analyzed similarly.

BIO/WEST was contracted by the U.S. Fish and Wildlife Service in 1977 to conduct a study in the Green River below Jensen to determine the habitat requirements of juvenile Colorado squawfish (Holden 1977). In 1978 and 1979, BIO/WEST sampled a station near Jensen in a Water and Power Resources Service funded project to determine effects of inlet modification of Flaming Gorge Dam (Holden and Crist 1978 and 1980). In 1979, BIO/WEST sampled a 20-mile section of river below Jensen for a proposed power plant (Holden and Selby 1979). Therefore, a section of the Green River between Jensen and Ouray, Utah, has been intensively studied for three consecutive years, and excellent data on Colorado squawfish reproductive success has been collected.

Table 1 summarizes the juvenile Colorado squawfish data for 1977-79 by age class. Fish were assigned an age on the basis of length/frequency histograms for 1979, shown in Figure 2 (Holden and Selby 1979) and those presented by Vanicek (1967) for 1964, 1965, and 1966. The numbers of fish shown in Table 1 can be very misleading if the amount of effort expended each year is not known. During 1977 a thorough seining survey was conducted of the entire river section between Jensen

Table 1. Numbers of Colorado squawfish caught by BIO/WEST in 1977, 1978, and 1979 by year class in the Green River between Jensen and Ouray, Utah.

Year of capture	Sampling effort	Year classes				
		1975	1976	1977	1978	1979
1977	High	14	8	0	-	-
1978	Low	-	6	0	17	-
1979	Very High	-	-	1	255	1131
Total		14	14	1	272	1131
Reproductive Success		Good	Good	Poor	Good	Good

and Ouray in August which included 106 seine hauls. Effort in 1978 included samples in April, June, July, August, and October of only about 2 miles of river near Jensen, including 28 seine hauls. Effort in 1979 included monthly samples from April through September of about 20 miles of the river reach in question, as well as 4 monthly samples in the 2-mile section at Jensen with 163 total seine hauls. Therefore, effort was high in 1977 and 1979, but relatively low in 1978.

The data presented in Table 1 indicates that success was good in 1975, 1976, 1978, and 1979. Success in 1977 was poor, and in fact was nearly non-existent in the Jensen-Ouray area. The only fish that may have been from the 1977 year class was a 5-inch specimen collected in May of 1979. Collections in 1977 were conducted during August

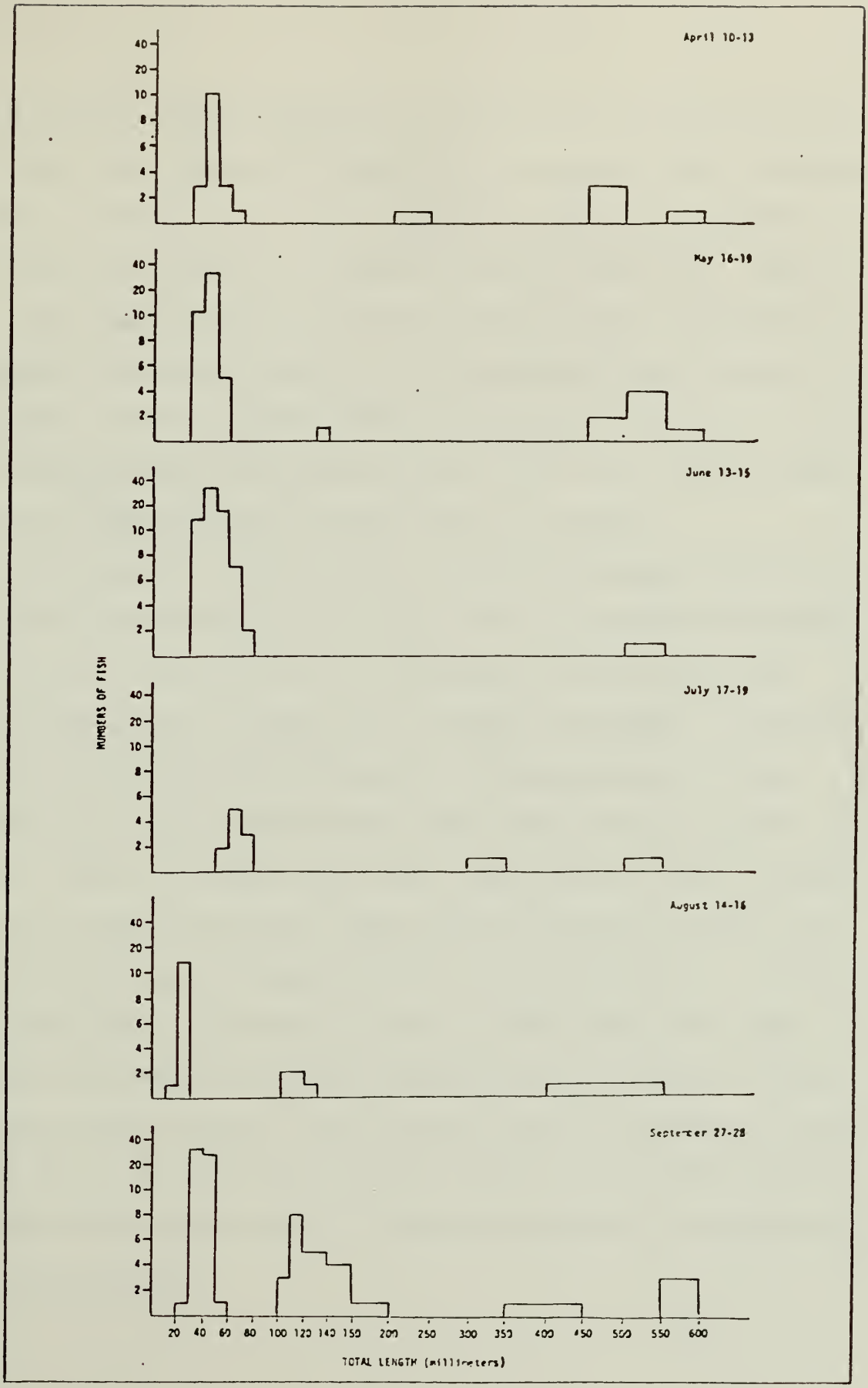

Figure 2. Length-frequency distribution of Colorado squawfish collected during the Moon Lake Project in the Green River, Utah, 1979 (from Holden and Selby 1979).

when young-of-the-year squawfish are generally first found (Vanicek and Kramer 1969, Holden and Selby 1979), but none were found. Sampling effort in 1978 was low but still produced six 1976 year class fish, 17 young-of-the-year, but no yearlings, the 1977 year class. There is little doubt that 1977 was in fact a very poor year for Colorado squawfish reproductive success in the area between Jensen and Ouray. Therefore the data in Table 1 accurately portrays reproductive status of Colorado squawfish for the period 1975-1979, and all years, except 1977, were reproductively successful for the squawfish.

Comparing this data with flows in 1975-1979 (Figures 3-7) shows that all years exhibited rather natural flows, except 1977 (Figure 5). The loss of a high spring flow, attributable to very little runoff from the Yampa River, appears to be the major factor that is different in the hydrograph for 1977 (Figure 5). During most years, a high spring peak occurs in either May or June, then recedes in late June and July. Also in all normal years (1975, 1976, 1978, and 1979), the major portion of the spring flow is Yampa River water because releases from Flaming Gorge Dam are regulated and do not exceed 4400 cfs. In 1977, the Green River provided most of the flow at the Jensen USGS gauge except during May and June when about one-half of the Jensen flow was due to the Yampa inflow. These data show that the Yampa River is very important to the success of Colorado squawfish in the upper Green River and that major reductions in its spring flow would be very detrimental to Colorado squawfish.

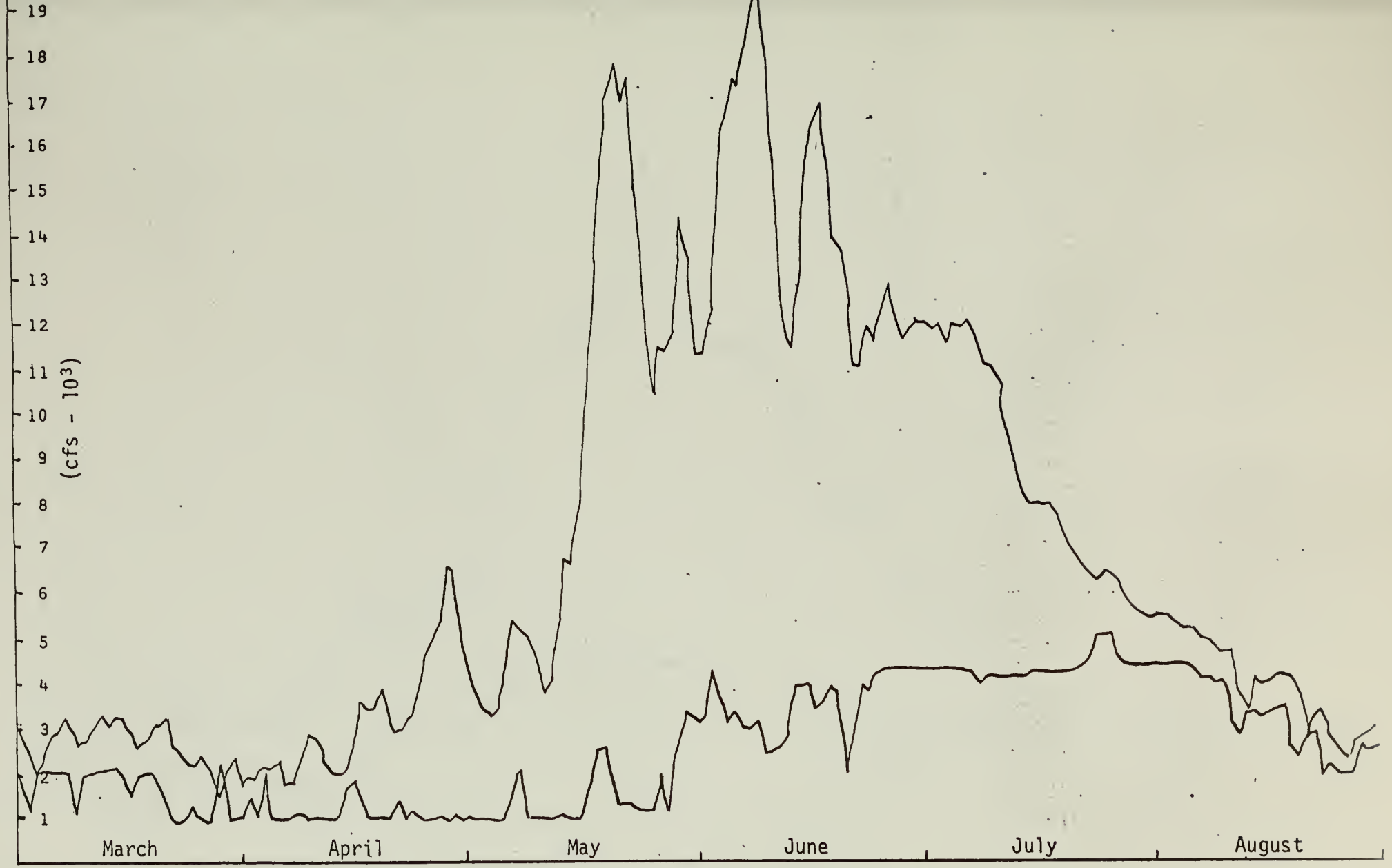

Figure 3. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1975.

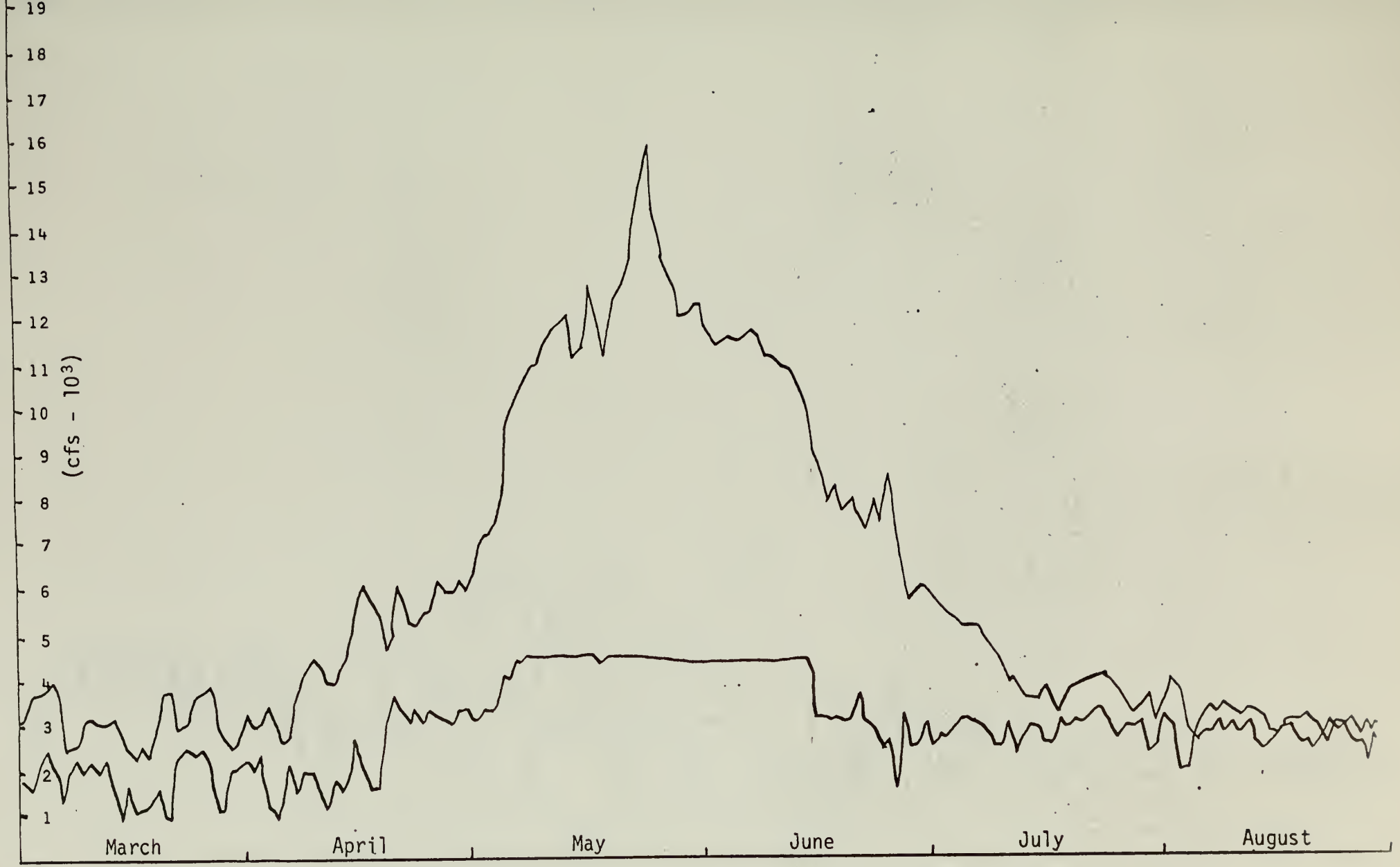

Figure 4. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1976.

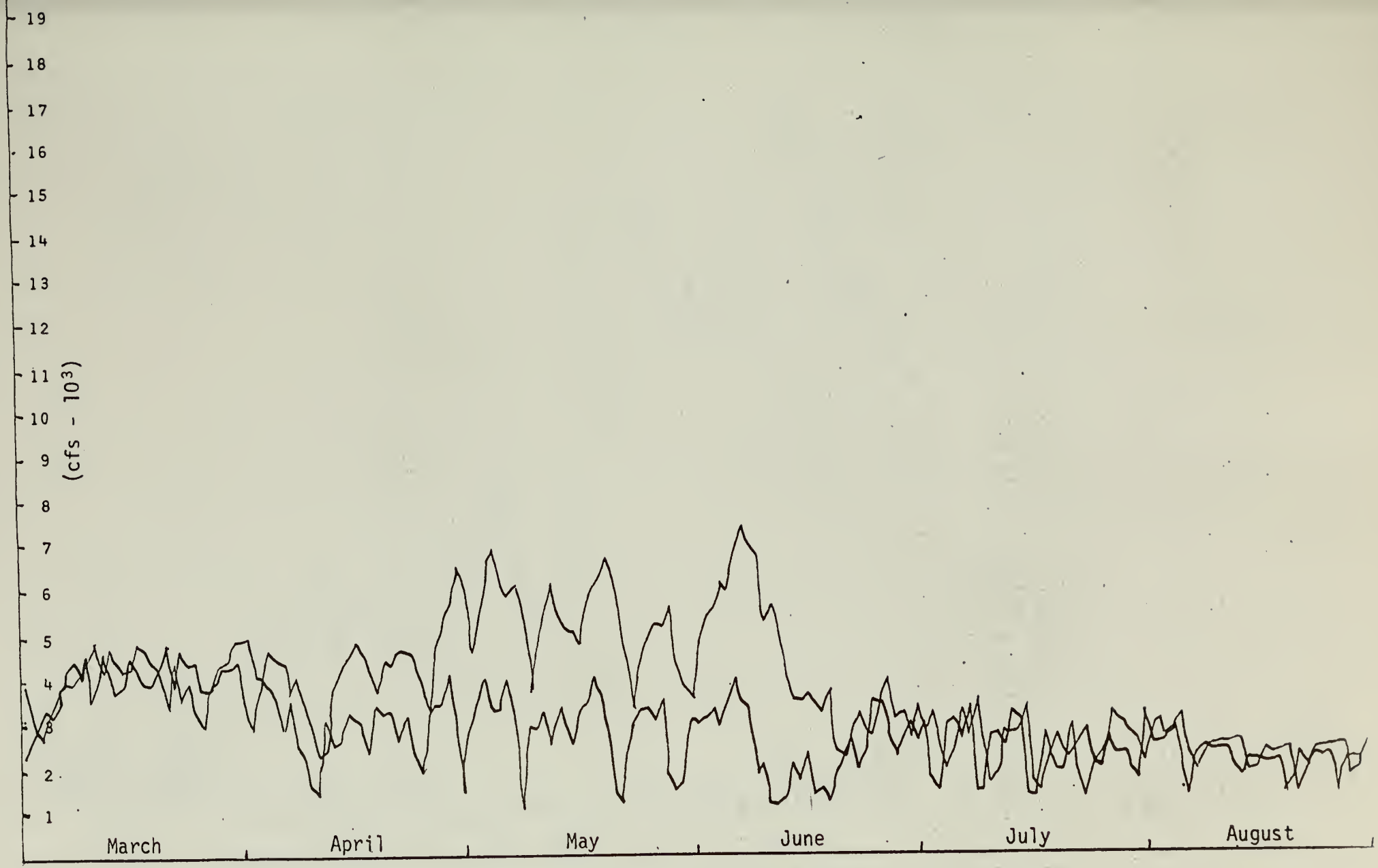

Figure 5. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1977.

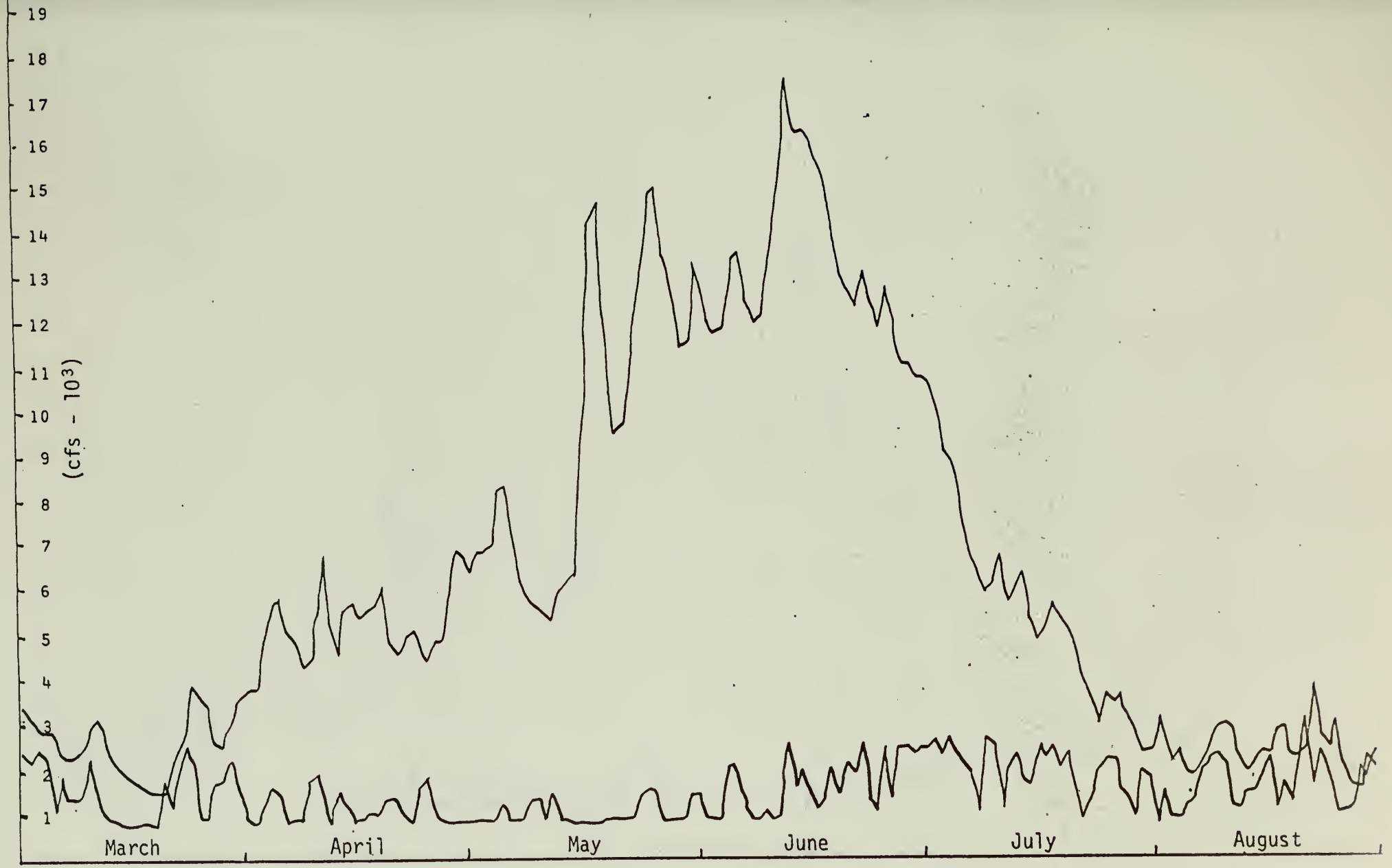

Figure 6. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1978.

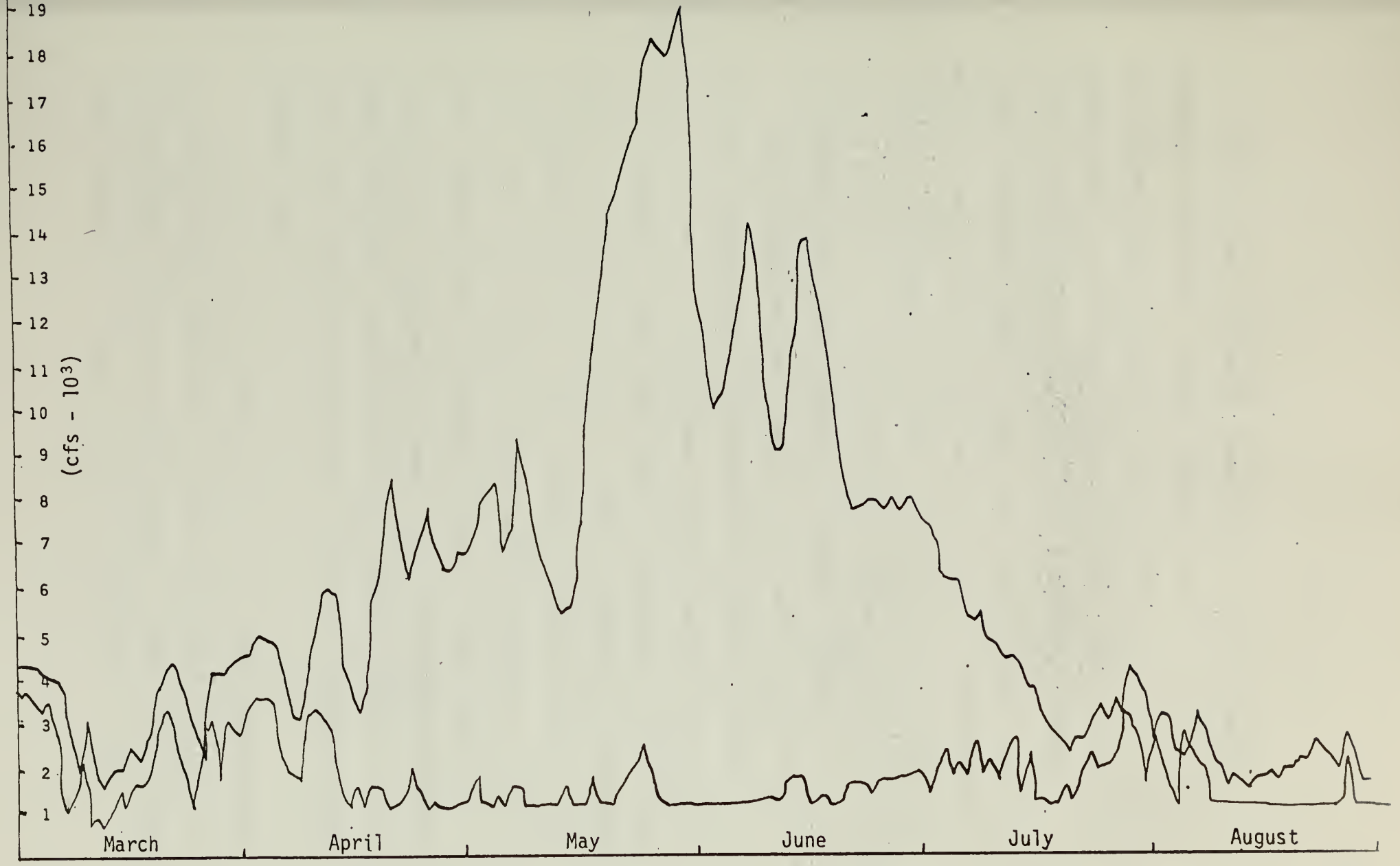

Figure 7. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1979.

Vanicek (1967) studied the Green River in Dinosaur National Monument in 1964-1966. The major objective of his study was to determine the downstream effects of Flaming Gorge Dam, which was closed in November 1962, on the fishes in the Green River. He sampled stations which included Echo Park, the confluence of the Green and Yampa rivers; Island Park, about 10 river miles below Echo Park; and Split Mountain, about 10 miles below Island Park. He also sampled several stations in the Green River between the mouth of the Yampa River and Flaming Gorge Dam. His seining effort was high and included several days of sampling at each station during 3 or 4 months each year.

Table 2 shows the young squawfish collected by Vanicek (1967). This data indicates that Colorado squawfish spawned in Dinosaur National Monument all years between 1962-1966, but that success was lower in 1965, and perhaps 1962, than the other years. The 1962 year class was not sampled until age II, when low numbers are usually found. It should be noted that in 1965, 4 members of the Age class III, 1962 cohort, were found, whereas in 1966, 5 members of the Age III, 1963 cohort, were collected. Since the 1963 year class was supposedly "strong" due to large numbers of Age I and II fish caught in 1964 and 1965, respectively, the capture of similar numbers of Age III fish indicates that 1962 may also have been a good year for squawfish reproductive success.

Figure 8 is the length/frequencies of young squawfish presented by Vanicek (1967). Collections in 1964 in June show large numbers of Age I fish which ranged from 30 mm to 80 mm. In 1965, Age I fish were 30-50 mm and Age II fish were indicated to be 55-110 mm in June.

Table 2. Numbers of Colorado squawfish caught by Vanicek (1967) in the Green River, 1964-1966 in Dinosaur National Monument by year class.

Year of capture	Sampling effort	Year classes				
		1962	1963	1964	1965	1966
1964	High	1	357	275	-	-
1965	High	4	29	53	42	-
1966	High	0	5	8	1	560
Total		5	391	336	43	560
Reproductive Success		Good	Good	Good	Poor	Good

These data suggest that some of the Age I fish caught in 1964 may actually have been Age II fish. A recent conversation with Dr. Vanicek indicated this was very possible. If this were so, the 1962 year class would not appear to be as small as indicated in Table 2. Therefore, it is concluded that 1962 was a good year for squawfish reproduction in Dinosaur National Monument because the available data suggests 1962 was a better year than was initially indicated by Vanicek (1967).

There is no data to suggest that 1965 was also a good year, for an analysis of Vanicek's data sheets indicates that effort in 1965 was similar to the other years of his study.

Most of the young squawfish collected by Vanicek (1967) were taken in Echo Park, although young squawfish were also taken in Island Park and Split Mountain. No young squawfish were taken in the Green River

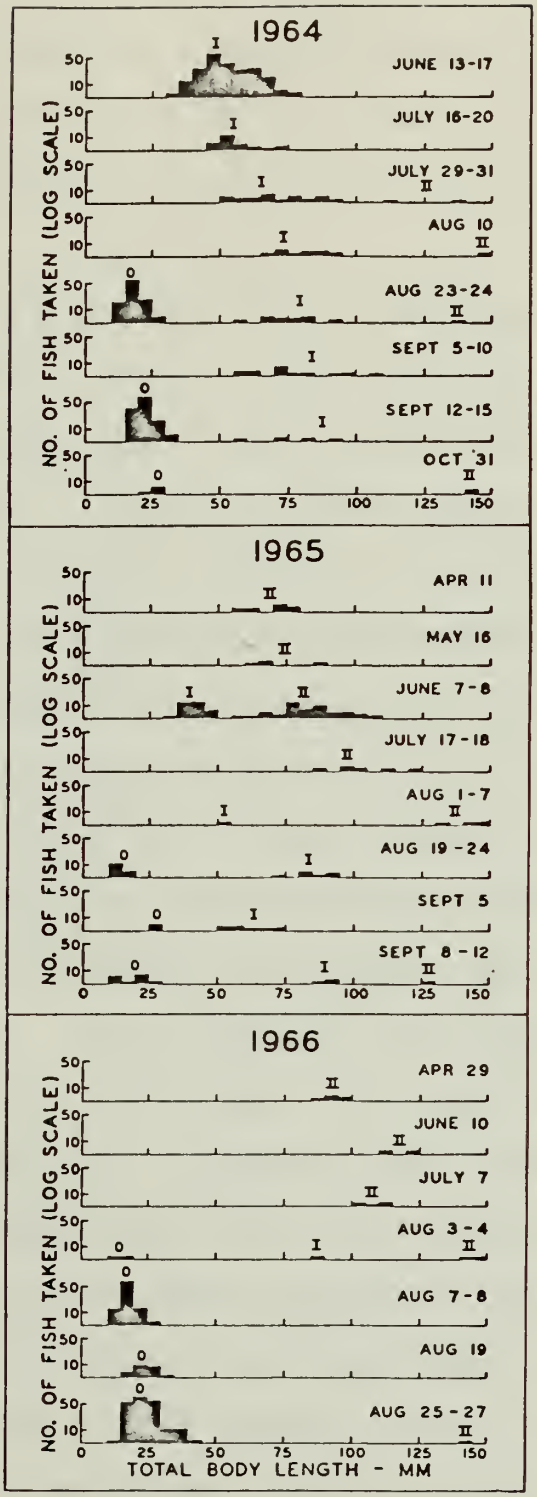

Figure 8. Length-frequency of young Colorado squawfish from the Green River, 1964-1966 (from Vanicek and Kramer 1969).

above the mouth of the Yampa River. Vanicek (1967) concluded that the Yampa River sufficiently ameliorated the cold temperatures of the Green such that fish populations below that point were little affected by the dam in 1963-1966.

Figures 9-13 show the hydrographs for the Green River during 1962-1966 at Jensen and Greendale. All years show a fairly normal seasonal flow pattern at Jensen, high in May or June, receding flow levels in July to lows in late summer. Flows from the Green River (Greendale) were fairly erratic and did not generally affect the seasonal pattern. The 1965 data does not show abnormal flows but rather appears to be a fairly normal flow year for the Yampa River, except that the highest peak occurred late in June, rather than during the more typical mid-late May period. This suggests that 1965 was a colder year than normal. Very high flows from Flaming Gorge Dam in March and April of 1965 produced an abnormal pattern for the Green River at Greendale, which also could have affected temperatures. Table 3 shows the mean monthly temperatures of the Green River at Jensen for 1962-1966. These data indicate that April, May, and June temperatures in 1965 were colder than 1963, 1964, or 1966, other post-impoundment years. The 1965 temperature pattern was probably created by the cold, ambient conditions causing the late runoff, as well as the large releases from Flaming Gorge Dam in April.

Several researchers have studied the Green and Yampa rivers from 1967 almost continuously to the present. Young-of-the-year squawfish have not been found commonly in Dinosaur National Monument since 1966. Kramer (Robert Kramer, unpublished field notes, Utah Coop. Fish. Res. Unit,

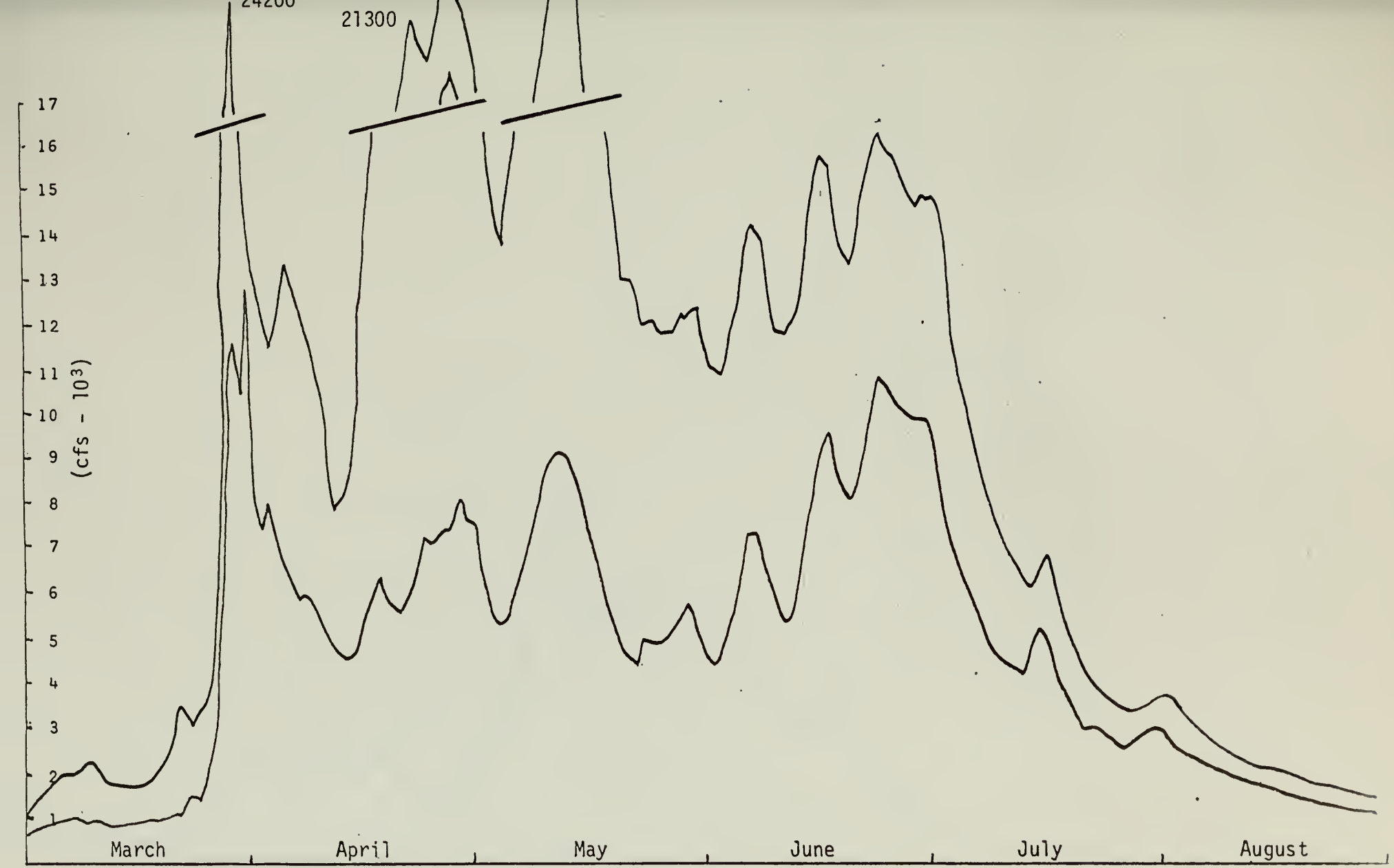

Figure 9. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1962.

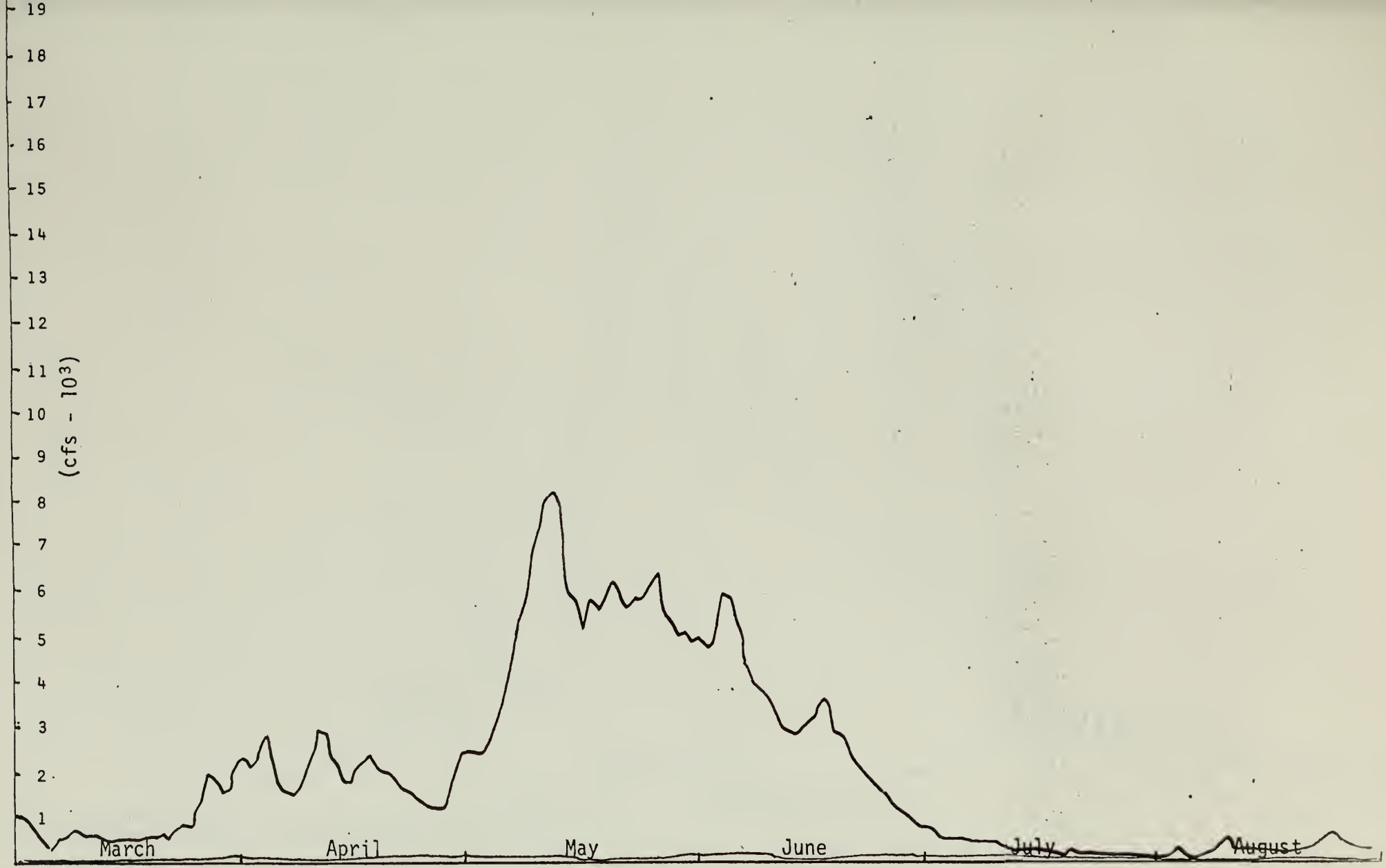

Figure 10. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1963.

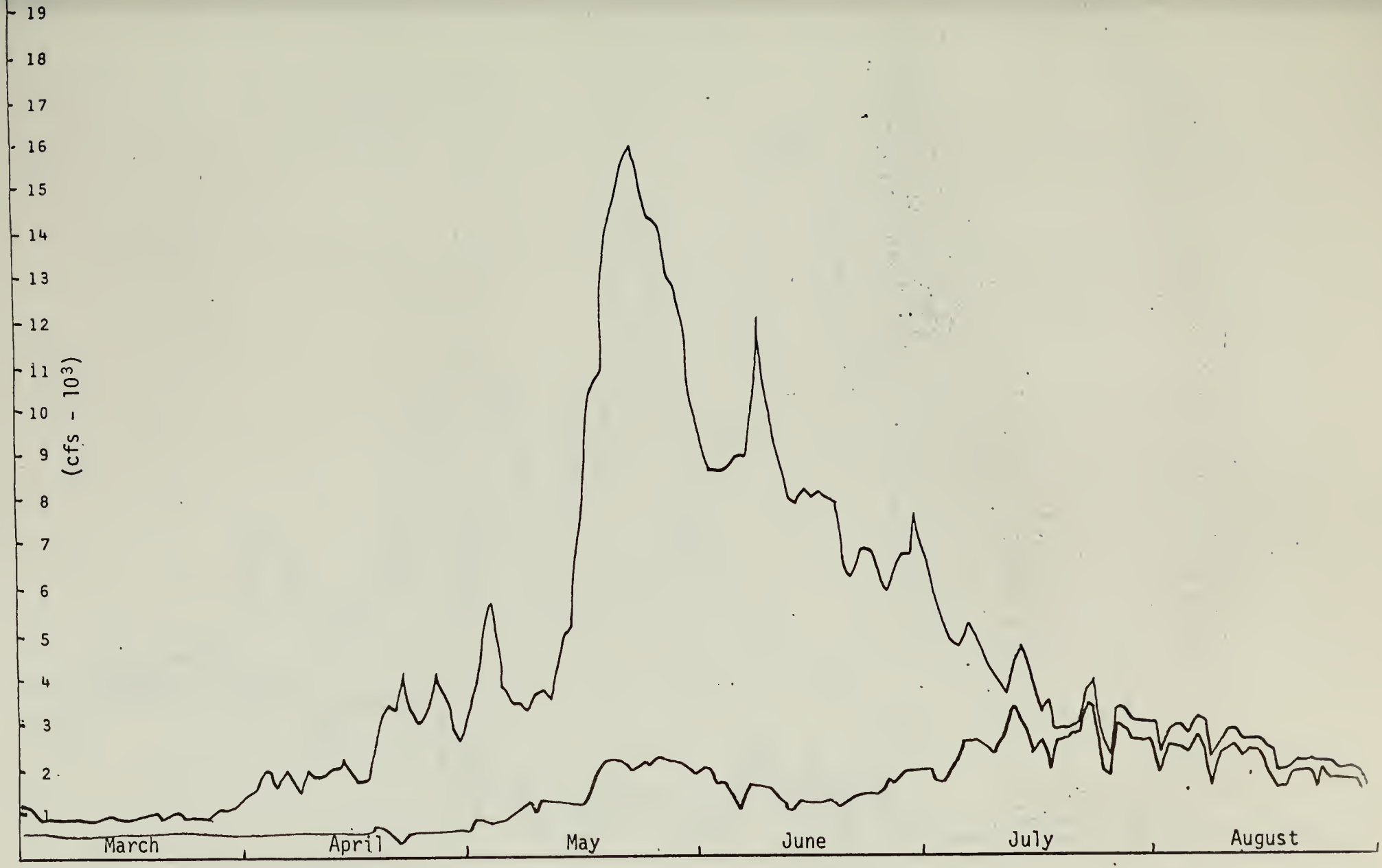

Figure 11. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1964.

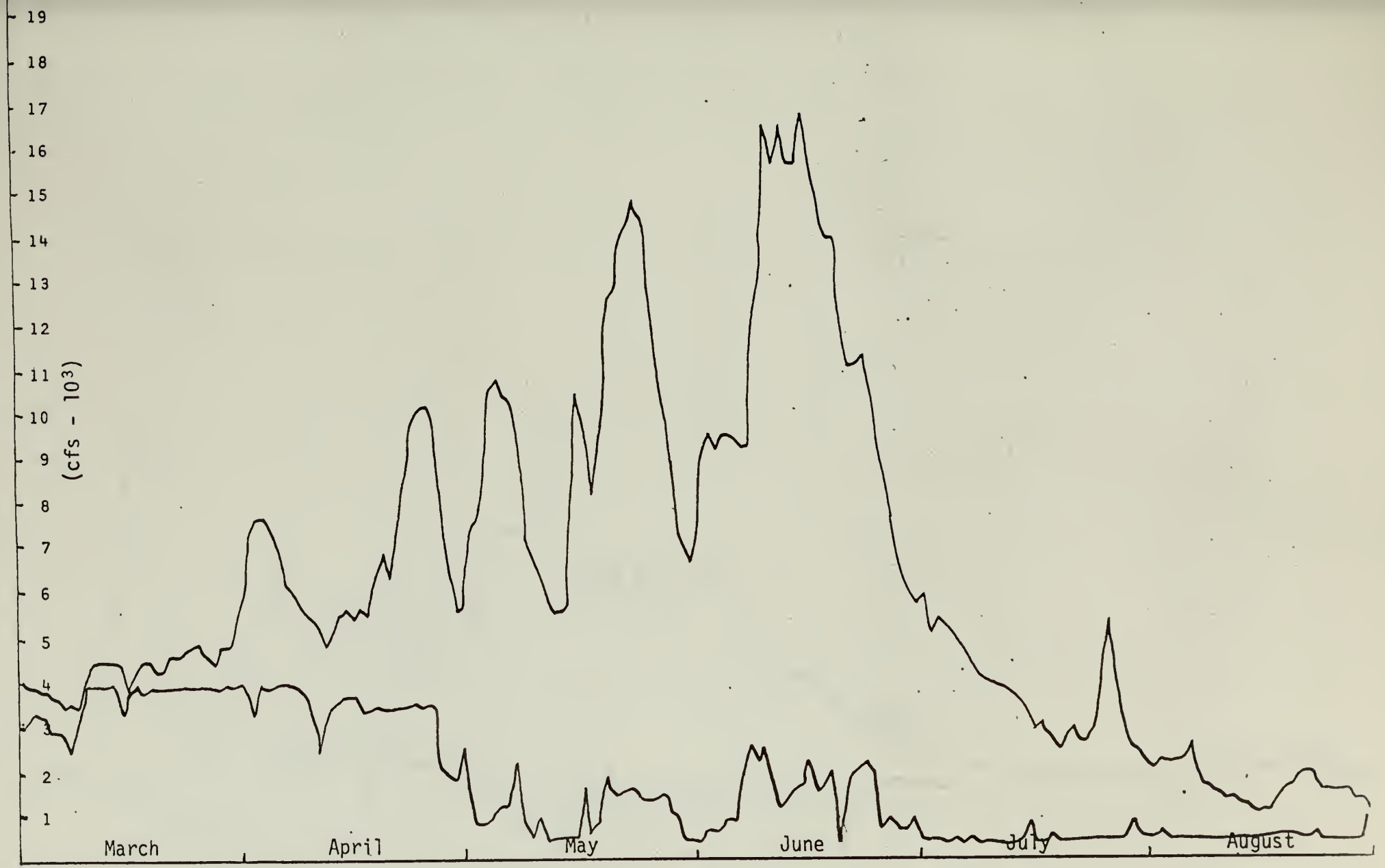

Figure 12. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1965.

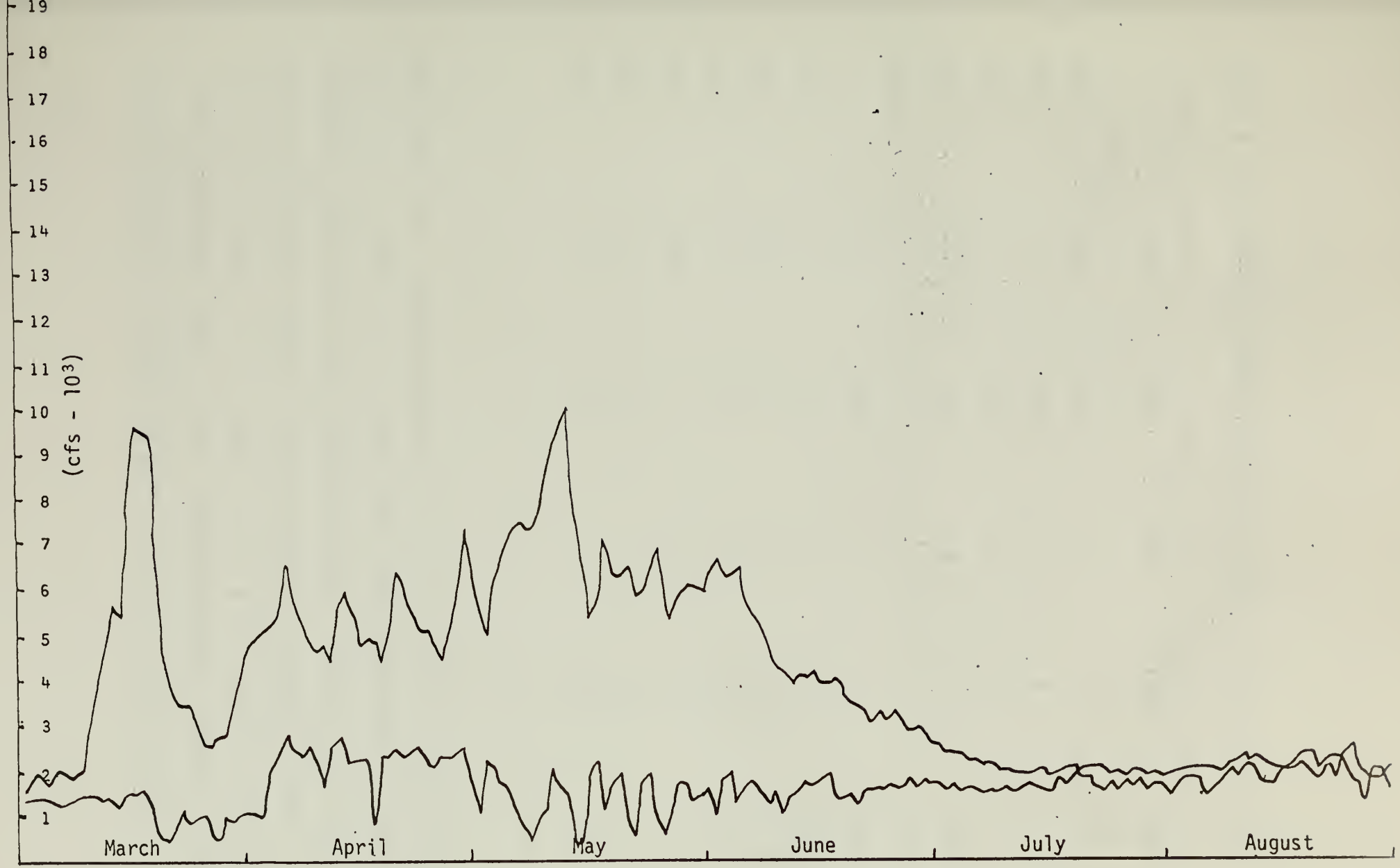

Figure 13. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1966.

Table 3. Mean monthly temperatures at the Jensen USGS gauge, 1962-1966.

	1962	1963	1964	1965	1966
Jan.	0.0	0.0	0	-	0
Feb.	-	0.6	0	2.2	-
Mar.	-	6.1	1.7	3.9	-
Apr.	10.0	9.4	8.9	7.2	9.4
May	12.8	15.0	13.3	12.2	14.4
June	17.2	18.9	16.1	15.6	16.7
July	21.1	22.2	18.9	19.4	20.0
Aug.	20.6	22.2	17.8	18.9	17.8
Sept.	17.2	18.9	15.0	13.9	14.4
Oct.	13.3	-	11.7	12.2	-
Nov.	6.7	5.5	-	8.3	-
Dec.	1.1	0.0	-	2.8	-

Utah State Univ., Logan) collected in Echo Park in 1967 as a continuation of Vanicek's (1967) work. He found fairly large numbers (69) of young squawfish, most of which were probably yearlings. Holden (1973) sampled Echo Park from 1968-1971 and found juvenile squawfish, probably either Age I or Age II fish in 1968, but only a few juveniles were found in 1969, and none in 1970 and 1971. Seethaler, McAda and Wydoski (1976) sampled portions of the Green and Yampa rivers in Dinosaur National

Monument in 1974-1976, but failed to find any young squawfish. Holden and Crist (1978) found three yearling squawfish in Island Park in 1978 and one yearling there in 1979 (Holden and Crist 1980). The seining effort expended by these researchers from 1967-1979 was considerably lower on a yearly basis than Vanicek's (1967) effort. Sampling varied from year to year, but sufficient effort was expended that young squawfish, at least a few, would have been found if they were present. The most intensive effort during these years was that of Holden and Crist (1979 and 1980). The low numbers of fish they found, and the failure to see any suggestion of good reproductive success, is similar to the conditions found by the other investigators from 1967-1977. These data show that reproductive success of Colorado squawfish essentially collapsed in about 1967-1968, changing from a strong reproductive position to one of essentially no reproductive success.

A similar collapse of the trophy trout fishery immediately below Flaming Gorge Dam also occurred in about 1967 or 1968. Holden and Crist (1978) showed that these simultaneous declines in the squawfish and trout populations were correlated with an increase in the flow released from Flaming Gorge since 1967, compared to the 1963-1966 period. Table 4 is a listing of mean monthly flows and temperatures at the Greendale USGS gauge for the periods 1951-1962 (pre-Flaming Gorge Dam), 1963-1966 (immediately after closure of Flaming Gorge), and 1967-1977 (normal operational mode for the dam). These data show that Flaming Gorge Dam had a tremendous impact on the natural flows and temperatures of the Green River, and that releases from 1963-1966 were fairly low.

Table 4. Mean daily flow (cfs) and temperature (°C) for the Green River at Greendale, Utah (0.5 MBD), 1951-1977 (U.S.G.S. data) (from Holden and Crist 1979).

	1951-62		1963-66		1967-77	
Month	Flow	Temp.[1]	Flow	Temp.	Flow	Temp.
Jan.	597	0.6	1497	5.0	2507	5.4
Feb.	792	0.6	1641	3.2	2265	4.4
Mar.	1413	2.2	1410	3.3	1692	4.3
Apr.	2752	7.2	1578	3.8	1765	4.4
May	4462	11.1	1009	4.6	2512	4.6
June	6996	15.5	1155	5.7	2535	5.0
July	3375	21.1	1178	6.9	2625	5.6
Aug.	1635	20.0	1128	7.8	2748	6.6
Sept.	913	15.5	1281	7.9	2327	7.6
Oct.	920	10.0	1192	10.0	2294	8.3
Nov.	814	1.7	1395	12.6	2501	9.0
Dec.	628	0.6	1511	8.7	2832	7.9

[1]Data for 1957-59 only.

After 1966 the mean monthly releases from the dam nearly doubled for all months except February, March, and April. Temperature of the released water also became colder after 1966 in June-September, although only by 1-2° C. Holden and Crist (1979) hypothesized that the increased quantity of colder water created cooler conditions in the river below the dam, thus affecting the trout fishery. They also suggested that

this greater mass of cold water must have remained cooler further down the river because ambient conditions were not able to raise the water temperature nearly as fast as it had during the low release period of 1963-1966. Therefore, squawfish reproduction in Dinosaur National Monument was reduced in about 1967 or 1968 because the Yampa River could no longer ameliorate the cold inflow of the Green River. Collections of young squawfish the past few years suggest the river does not return to a normal temperature pattern until it reaches the Jensen area.

Additional data could be presented to indicate Colorado squawfish reproductive success in portions of the Upper Colorado basin. Unfortunately no other areas than the two discussed above have more than one or two years of data. Holden (1973) found young-of-the-year squawfish to be quite common in the lower Green River in Canyonlands National Park in 1970 and 1971. He also found yearlings to be quite common between Ouray and Gray Canyon as well as a few young-of-the-year in 1971. These data would suggest that squawfish did spawn successfully in much of the Green River in 1970 and 1971, years of normal flow patterns (Figures 14 and 15).

As mentioned earlier, Holden (1977) sampled the Jensen-Ouray area in August, 1977, and also continued downstream to Green River, Utah, in September. Young-of-the-year squawfish were not found in 1977 between Ouray and Gray Canyon, but were found at a point about 25 miles upstream from Green River. This data reinforces the conclusion that 1977 was a very poor year for Colorado squawfish reproductive success in the Green River, at least above Gray Canyon (Figure 16).

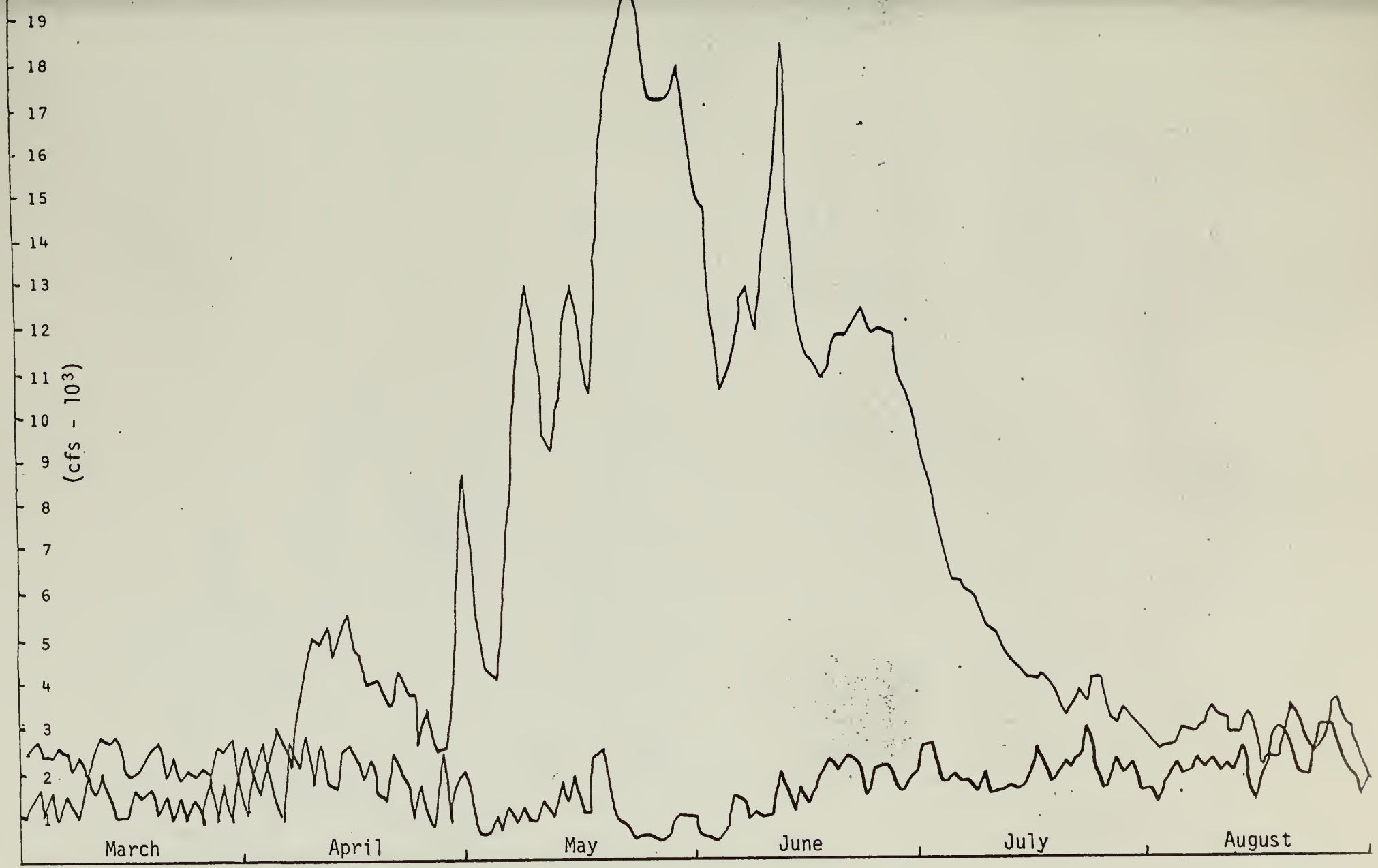

Figure 14. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1970.

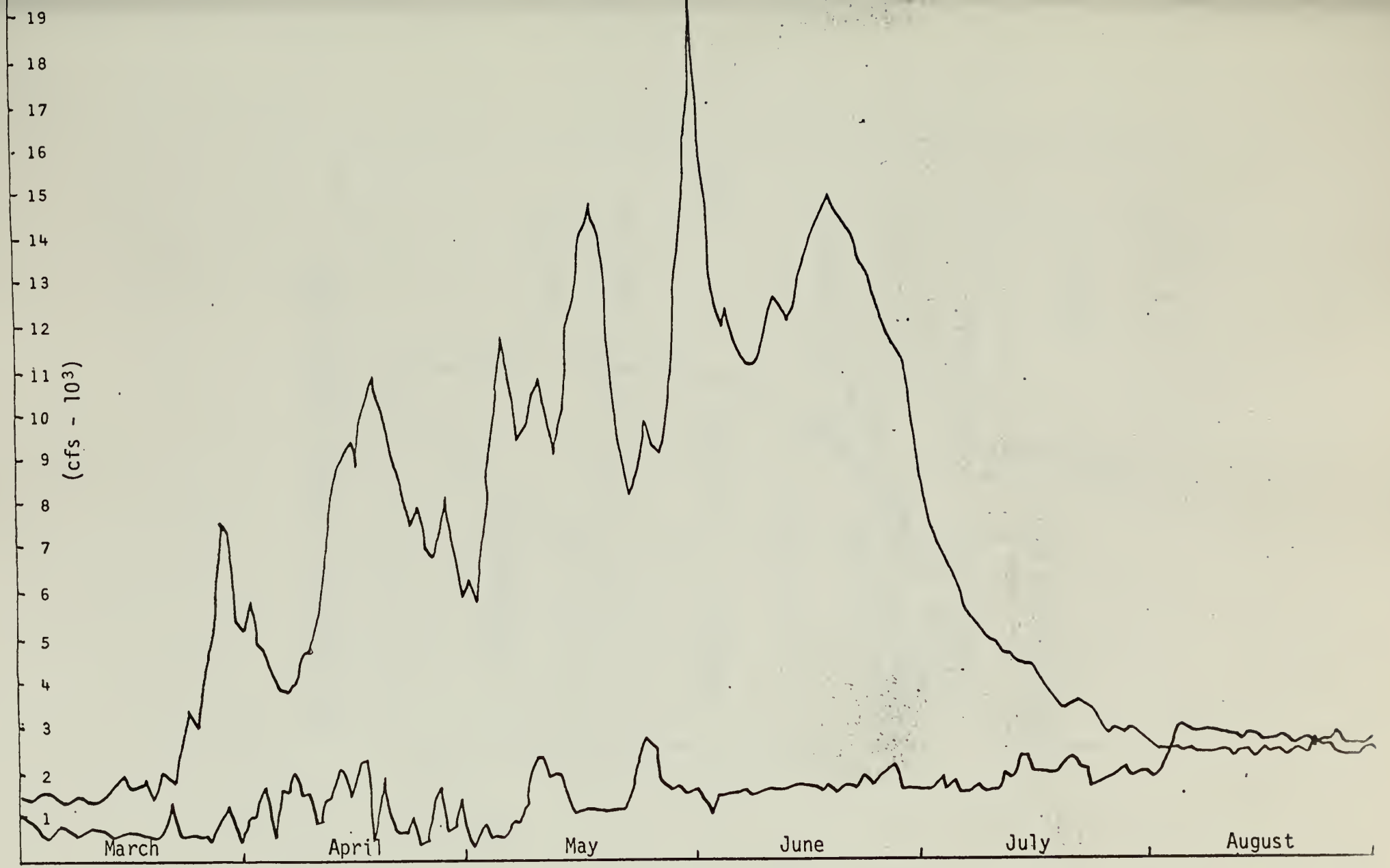

Figure 15. Hydrograph for the Green River at Jensen (upper) and Greendale (lower) in 1971.

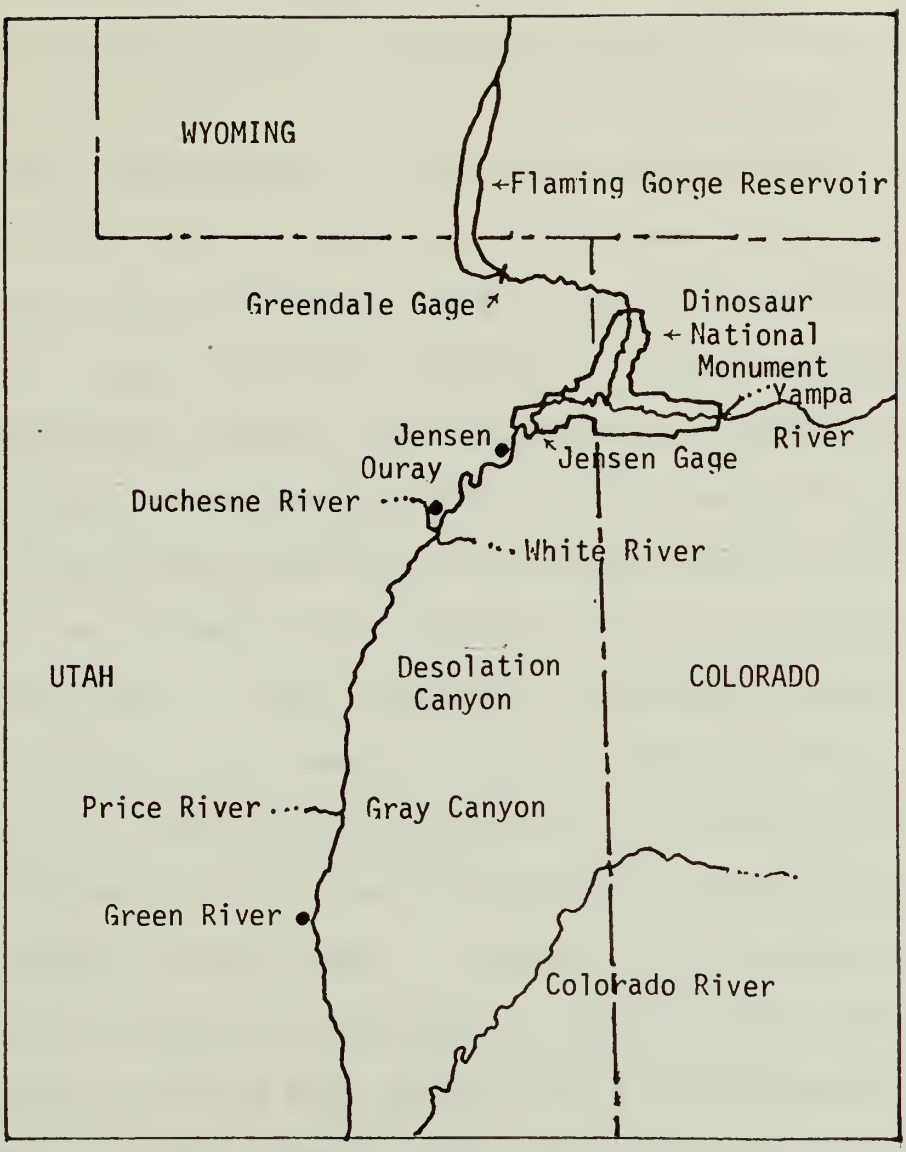

Figure 16. Map of the Green River system showing USGS gauges and other landmarks indicated in the text.

The relationship between flow and reproduction of other rare fish has not been established primarily because insufficient young have been found to indicate success. Available information indicates that the bonytail chub and razorback sucker require large rivers for their existance. This statement is supported in that relatively few of these species are found in tributaries, even the Yampa River, as compared to the numbers found in the mainstem Green and Colorado rivers. This information suggests that these large river forms either have a direct requirement for particular flows and/or that the habitat needed for these fishes is maintained by large flows. No young-of-the-year Colorado squawfish have been found in the Yampa River above its mouth, even though they reproduced in the Green River when it contained almost 100% Yampa River water in 1963 (Figure 11). It appears therefore that large river habitat is very important to the maintenance of these rare fish populations. Since the Green River is now regulated by Flaming Gorge Dam, the Yampa represents most of the Green's flow below Echo Park for most of the spring and summer. Therefore, it is the Yampa, and other downstream tributaries such as the Duchesne and White rivers, that are maintaining the Green as a "large river," and thereby maintaining one of the last potential habitats for these large river fishes.

Data at present suggests the bonytail chub may be very near extinction in the Green River. Vanicek (1967) collected over one hundred adults in the three years of his study in Dinosaur National Monument. These fish were used in a taxonomic study by Holden and Stalnaker (1970). Holden (1973) collected only 36 adults in the four year of his study in

the Upper Colorado basin. He also examined collections of juvenile chubs made by Vanicek (1967) and found only three possible juvenile bonytails from 1964-66 collections. More recent studies have also failed to find many bonytails (Seethaler, McAda and Wydoski 1976; Holden 1977; Holden and Crist 1978). Therefore, it appears that bonytails started disappearing in the early 1960's, corresponding to the closure of Flaming Gorge Dam, and indications are that loss of reproduction may have been a major reason. The apparent decline in bonytails throughout the Green River system suggests that the effect of Flaming Gorge Dam was more than just a lowering of river temperatures for about one hundred miles below the dam, and that loss of flow may have been a significant factor. Loss of natural flows from tributaries to the Green, especially the Yampa River, may cause the other already rare fishes to come closer to extinction, much as the bonytail already has come.

FACTORS AFFECTING COLORADO SQUAWFISH REPRODUCTIVE SUCCESS

The data presented in this report indicates that abnormal spring flows are correlated with poor Colorado squawfish reproductive success in about 150 miles of the Green River in 1977, the only year studied with non-natural flows. Abnormally cold temperatures created by cold releases from Flaming Gorge Dam caused poor squawfish success from 1967-1977 in the Green River from Echo Park to Jensen. Squawfish reproductive success in Dinosaur National Monument was low in 1965, even though it was very much better than that seen after 1967 in the same area, or in 1977 from Jensen to Gray Canyon. Abnormally cold spring temperatures appear to be the most likely reason for the low success in 1965.

The information presented herein raises the question—was temperature also the primary factor in 1977? Table 5 shows the mean monthly temperature at Jensen for 1975-1979. These data show that temperatures in 1977 were intermediate between years of successful squawfish reproduction, as 1975 and 1976 were generally cooler than 1977, and 1978 and 1979 were generally warmer, except for June when 1977 was warmest. Another way to look at temperatures is the number of days above a certain level, during a given period of time. This approach reflects the daily temperature, rather than the monthly mean. Table 6 shows the number of days the river temperature was at or above 60° F or 15° C by June 30 at Jensen for 1962-1966 and 1975-1979. The values of 60° F and 15° C are used because the U.S.G.S. recorded temperatures in °F until 1968, when they switched to °C. The data in Table 6 show that 1965 had considerably fewer days above 60° F than any other year from 1962-1966. Temperatures in 1977, however, were intermediate in terms of 15° C days. The conclusion from this data is that temperature was not a factor causing poor success in 1977.

The discussion of temperatures in 1977 raises the point of the relationship between flow and temperature. Obviously, temperature is dependent on ambient weather conditions, which warm the water, and flow or water quantity. The greater the volume of water, the lower the warming potential of a given set of weather conditions. Since closure of Flaming Gorge Dam, temperatures have been colder at Jensen because of the cold releases from the dam. Yampa River temperatures have been natural and therefore vary with ambient conditions, as well as flow

Table 5. Mean monthly water temperatures, Jensen U.S.G.S. gauge, 1975-1979.

Month	1975	1976	1977	1978	1979
Jan.	1.0	-	2.5	1.0	0
Feb.	2.0	2.5	4.5	1.5	2.9
Mar.	4.5	5.5	4.5	6.2	4.9
Apr.	8.0	10.0	8.0	9.4	9.6
May	11.5	13.0	13.0	12.2	17.1
June	14.0	15.5	21.0	-	19.5
July	18.0	19.0	18.5	20.0	23.6
Aug.	17.0	-	18.0	19.6	21.1
Sept.	16.5	-	15.0	16.0	19.3
Oct.	9.0	-	9.9	-	12.3
Nov.	5.0	4.0	5.4	-	-
Oct.	-	3.5	2.5	-	-

Table 6. Number of days above 60° F or 15° C at the Jensen gauge by June 30 of each year.

Year	Days above 60° F	Year	Days above 15° C
1962	27	1975	13
1963	46	1976	26
1964	28	1977	35
1965	17	1978	50
1966	33	1979	63

level. Temperature patterns were slightly altered in 1977, but the reason for this abnormality was reduced Yampa River flows.

The data presented above show that Colorado squawfish require natural flow in order to reproduce effectively. It appears that the pattern of flow, i.e., a spring peak, is important, as is the actual quantity of flow. Temperature can affect successful reproduction, especially if spawning temperatures are not met, and this effect can override the flow requirement. Regulation of the flow of the Yampa River would undoubtedly have serious consequences on Colorado squawfish reproductive capabilities. Regulated flows may be lower than those required by squawfish for successful reproduction. Temperatures of lower flows would be more subject to variation caused by ambient conditions. The combination of regulated flows in both the Green and

Yampa could have disastrous consequences, and the coordination necessary to produce normal flow and temperature patterns from dams on both rivers would probably negate the power producing potential of the systems involved. Squawfish reproduction in Dinosaur National Monument is expected to be improved considerably by the recent inlet modifications in Flaming Gorge Dam. Regulation of the Yampa River would probably negate this potential for resurrection of past spawning conditions.

CONCLUSION

The data presented in this report indicate that the flow of the Yampa River is very important in regard to the successful maintenance of rare Colorado River fishes in the Green River. Normal spring flows from the Yampa River are highly correlated with success of Colorado squawfish reproduction in the upper Green River. The bonytail chub and razorback sucker, as well as the Colorado squawfish, require large river habitat for their survival, and the flows in the Green River system are apparently already too low to provide sufficient habitat for the bonytail chub. The Yampa River is the main source of flow to the Green River and, therefore, is the major reason the large river fishes still exist in the Green.

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